CS 112  Introduction to Programming

(Spring 2012)

Lecture #38: Final Review; Critter Tournament

Zhong Shao

Department of Computer Science
Yale University
Office: 314 Watson

http://flint.cs.yale.edu/cs112

Acknowledgements: some slides used in this class are taken directly or adapted from those accompanying the two textbooks: Introduction to Programming in Java: An Interdisciplinary Approach by Robert Sedgewick and Kevin Wayne and Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp
Course Overview (From Lecture 1)

What is CS112?
- A broad, programming-centric introduction to computer science

Goals.
- Demystify computer systems
- Empower you to exploit available technology
- Build awareness of substantial intellectual underpinnings

Topics
- Programming in Java
- Key program design techniques & problem-solving skills
- Programming tools & important libraries and data structures
- Applications to science, engineering, and commercial computing

“Computers are incredibly fast, accurate, and stupid; humans are incredibly slow, inaccurate, and brilliant; together they are powerful beyond imagination.” — Albert Einstein
Final Review

Final Exam: 2:00pm – 4:00pm, DAVIS AUD
Tuesday, May 1st, 2012,

For more info about the final exam, please see:

http://zoo.cs.yale.edu/classes/cs112/lectures/exam2
Topic: Static/Instance Methods/Variables: I am confused
Static Variable

- A variable declared with the `static` modifier
  - **Behavior:**
    - has a single copy across the whole program
    - is created and initialized when the program starts
  - **Why (example usage)?**
    - class-wide counters to keep track the number of objects created from the class
    - single instance object, e.g., `out` is a static variable in the `System` class
Static Methods

- Intention: reflect common class behaviors, not dependent on any instance of objects
  - A static method can be either public or private; the order of the modifiers such as public/private/static can be interchanged, but by convention visibility modifiers come first.

- Invocation:
  - Inside class definition: just call the method name
  - Outside class definition: ClassName.methodName(…)


**Static Method Invocation**

```java
class Tester {
    public static int triple (int num) {
        int result;
        result = num * 3;
        return result;
    }
    ...
}

value = Tester.triple (5);

// It is possible to invoke a static method through an object:
Tester t = new Tester();
value = t.triple (5);
```
Instance Methods

- **Intention**
  - reflect the behaviors of objects created from the class, depends on individual objects’ states
  
  - instance methods can be accessed **only** through an object:
    
    ```java
    ClassName objVar = new ClassName(...);
    objVar.methodName(...);
    ```

  - can access both instance and class/static variables
Scoping and Access Rule

- **Class-scope variables**
  - *static variables*: can be accessed (in scope) in all methods in the class; outside the class, depends on public/private modifier (ClassName.staticVarName)
  - *instance variable*: can be accessed (in scope) in instance methods defined in the class; outside the class, depends on public/private modifier (objVarName.varName)

- **Block-scope variables**
  - can be accessed in the enclosing block
  - a local variable (method parameter) can shadow a class-scope variable with the same name
    - Use this to access the shadowed class-scope variable
Class-Scope Variables and Methods in a Class

Accessibility of variables in methods defined in the same class

<table>
<thead>
<tr>
<th>Static/class variable</th>
<th>Static/class method</th>
<th>Instance method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can access</td>
<td>Can access</td>
<td>Can access</td>
</tr>
</tbody>
</table>

| Instance variable      | Can not access      | Can access      |
Topic: Parameter Passing and Method Invocation
Basic Rule: Calling a Method

- Each time a method is called, each *actual argument* in the invocation is copied into the corresponding *formal argument*
  - if a value type, then it is the *value* that is copied
  - if a reference type, then it is the *reference* that is copied
    - Objects and arrays are reference types
- The formal argument and the actual argument are *different* variables, with different memory locations, even if they have the same name
Calling a Method: Value

```java
public int SquareSum (int num1, int num2)
{
    num1 = num1 + num2;
    return num1 * num1;
}
```

```java
int num = SquareSum (num1, num2);
```

```java
int num2 = 3;
int num1 = 2;
```

```java
int num = SquareSum (num1, num2);
```

```java
2
3
5
25
```
Calling a Method: Reference

Account bobAcct = new Account("Bob", 22222, 200.0);
double balance = 0;
doubleBalance (bobAcct);

static void doubleBalance(Account act)
{
    double balance = act.getBalance();
    act.setBalance( balance * 2 );
}

acctNumber = 22222
acctName = "Bob"
balance = 400.00

acct

balance

bobAcct

balance

0

200
Example: Parameter Passing

```java
public class Num {
    private int value;
    public Num(int update) {
        value = update;
    }

    public void setValue(int update) {
        value = update;
    }

    public String toString() {
        return value + "\n";
    }
}
```
Tracing the Parameters:

Before `changeValues()`

```
public static void main(String[] args) {
    int a1 = 111;
    Num a2 = new Num(222);
    Num a3 = new Num(333);
    changeValues(a1, a2, a3);
}
```

```
public void changeValue(int f1, Num f2, Num f3) {
    f1 = 999;
    f2.setValue(888);
    f3 = new Num(777);
}
```
Tracing the Parameters:

In `tester.changeValues(a1, a2, a3)`

```
public static void main(String[] args) {
    int a1 = 111;
    Num a2 = new Num(222);
    Num a3 = new Num(333);
    changeValues(a1, a2, a3);
}
```

```
public void changeValue(int f1, Num f2, Num f3) {
    f1 = 999;
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public static void main(String[] args) {
    int a1 = 111;
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    changeValues(a1, a2, a3);
}

public void changeValues(int f1,
                         Num f2, Num f3) {
    f1 = 999;
    f2.setValue(888);
    f3 = new Num(777);
}

Tracing the Parameters: f1=999
Tracing the Parameters: \( f_2.setValue(888) \)

```java
public static void main(String[] args) {
    int a1 = 111;
    Num a2 = new Num(222);
    Num a3 = new Num(333);
    changeValues(a1, a2, a3);
}

public void changeValues(int f1, Num f2, Num f3) {
    f1 = 999;
    f2.setValue(888);
    f3 = new Num(777);
}
```
Tracing the Parameters:
\[ f_3 = \text{new Num}(777) \]

```
public static void main(String[] args) {
    int a1 = 111;
    Num a2 = new Num(222);
    Num a3 = new Num(333);
    changeValues(a1, a2, a3);
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}
Topic: Inheritance, Method Invocation and Polymorphism
Basic Rule

- Java is dynamic binding: the method invoked is always the type of the object, not the type of the variable
Exercise: A Polymorphism Problem

Suppose that the following four classes have been declared:

```java
public class Foo {
    public void method1() {
        System.out.println("foo 1");
    }
    public void method2() {
        System.out.println("foo 2");
    }
    public String toString() {
        return "foo";
    }
}

public class Bar extends Foo {
    public void method2() {
        System.out.println("bar 2");
    }
}

public class Baz extends Foo {
    public void method1() {
        System.out.println("baz 1");
    }
    public String toString() {
        return "baz";
    }
}

public class Mumble extends Baz {
    public void method2() {
        System.out.println("mumble 2");
    }
}
```
A Polymorphism Problem

What would be the output of the following client code?

```java
Foo[] pity = {new Baz(), new Bar(), new Mumble(), new Foo()};
for (int i = 0; i < pity.length; i++) {
    System.out.println(pity[i]);
    pity[i].method1();
    pity[i].method2();
    System.out.println();
}
```
Finding output with tables

<table>
<thead>
<tr>
<th>method</th>
<th>Foo</th>
<th>Bar</th>
<th>Baz</th>
<th>Mumble</th>
</tr>
</thead>
<tbody>
<tr>
<td>method1</td>
<td>foo 1</td>
<td></td>
<td>baz 1</td>
<td></td>
</tr>
<tr>
<td>method2</td>
<td>foo 2</td>
<td>bar 2</td>
<td></td>
<td>mumble 2</td>
</tr>
<tr>
<td>toString</td>
<td>foo</td>
<td></td>
<td>baz</td>
<td></td>
</tr>
</tbody>
</table>
# Finding output with tables

<table>
<thead>
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<th>Foo</th>
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</tr>
</thead>
<tbody>
<tr>
<td>method1</td>
<td>foo 1</td>
<td></td>
<td>baz 1</td>
<td></td>
</tr>
<tr>
<td>method2</td>
<td>foo 2</td>
<td>bar 2</td>
<td></td>
<td>mumble 2</td>
</tr>
<tr>
<td>toString</td>
<td>foo</td>
<td></td>
<td>baz</td>
<td></td>
</tr>
</tbody>
</table>
## Finding output with tables

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<th>Bar</th>
<th>Baz</th>
<th>Mumble</th>
</tr>
</thead>
<tbody>
<tr>
<td>method1</td>
<td>foo 1</td>
<td><em>foo 1</em></td>
<td>baz 1</td>
<td>baz 1</td>
</tr>
<tr>
<td>method2</td>
<td>foo 2</td>
<td>bar 2</td>
<td><em>foo 2</em></td>
<td>mumble 2</td>
</tr>
<tr>
<td>toString</td>
<td>foo</td>
<td><em>foo</em></td>
<td>baz</td>
<td>baz</td>
</tr>
</tbody>
</table>
Use Diagramming

- Add classes from top (superclass) to bottom (subclass).
- Include all inherited methods.
Polymorphism Answer

```java
Foo[] pity = {new Baz(), new Bar(), new Mumble(), new Foo()};
for (int i = 0; i < pity.length; i++) {
    System.out.println(pity[i]);
    pity[i].method1();
    pity[i].method2();
    System.out.println();
}
```

- **Output:**
  - baz
  - baz 1
  - foo 2
  - foo
  - foo 1
  - bar 2
  - baz
  - baz 1
  - mumble 2
  - foo
  - foo 1
  - foo 2
Exercise 2:

- The methods sometimes call other methods (tricky!).

```java
public class Ham {
    public void a() {
        System.out.print("Ham a   ");
        b(); // whose b()? Ham's?
    }
    public void b() {
        System.out.print("Ham b   ");
    }
    public String toString() {
        return "Ham";
    }
}

public class Lamb extends Ham {
    public void b() {
        System.out.print("Lamb b   ");
    }
}
```
What would be the output of the following client code?

```java
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};
for (int i = 0; i < food.length; i++) {
    System.out.println(food[i]);
    food[i].a();
    System.out.println(); // to end the line of output
    food[i].b();
    System.out.println(); // to end the line of output
}
```
Class Diagram

Ham
\a0
\b0
\text{toString}\0

Lamb
\a0
\b0
\text{toString}\0

Yam
\a0
\b0
\text{toString}\0

Spam
\a0
\b0
\text{toString}\0
<table>
<thead>
<tr>
<th>method</th>
<th>Ham</th>
<th>Lamb</th>
<th>Yam</th>
<th>Spam</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Ham a</td>
<td></td>
<td>Yam a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b()</td>
<td></td>
<td>super.a()</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td>Ham b</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lamb b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>toString</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yam</td>
<td></td>
</tr>
<tr>
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<tr>
<td>--------</td>
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<td></td>
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<td>b</td>
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<td>Lamb b</td>
<td></td>
<td>Spam b</td>
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<td></td>
<td>Yam</td>
<td></td>
</tr>
</tbody>
</table>
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};
for (int i = 0; i < food.length; i++) {
    System.out.println(food[i]);
    food[i].a();
    food[i].b();
    System.out.println();
}

Output:
Ham
Ham a   Lamb b
Lamb b
Ham
Ham a   Ham b
Ham b
Yam
Yam a   Ham a   Spam b
Spam b
Yam
Yam a   Ham a   Lamb b
Lamb b
Common Questions We Saw: OO

- The role of "this" and "super" keywords
- Correctly overriding methods in OOP
- Benefits/implications of the "static" keyword, particularly in an OOP context
Bulldog Critters